OFF-ROAD RECREATIONAL VEHICLES
SNOWMOBILES & FOUR-WHEEL DRIVE VEHICLES
(Updated - April 1994)

CATEGORY OF EMISSION SOURCE NUMBERS AND DESCRIPTION

47514 Recreational . Off-Road Motor Vehicles . Gasoline-Combustion . Snowmobiles

54411 Recreational . Off-Road Motor Vehicles . Gasoline-Combustion . Four-Wheel Drives

EMISSION INVENTORY CODES AND DESCRIPTION

850-870-1100-0000 Snowmobiles

850-870-1100-0000 Four-Wheel Drive Vehicles

METHOD DESCRIPTION

These categories are used to inventory the combustion emissions from snowmobiles and the recreational off-road use of four-wheel drive vehicles. The results of this inventory are presented in Table I (CES 47514) and Table II (CES 54411).

The number of registered four-wheel drive vehicles by county are available from the Department of Motor Vehicles.[1] A number of the vehicles used solely for off-road recreation are not registered. In 1977, Tyler Research Associates[2] conducted a study for Caltrans to determine: 1) the relationship between the number of registered off-road vehicles and the actual number of off-road vehicles in use, and 2) the average fuel consumption per vehicle by month. The results of this study, particularly the correction factors to estimate actual vehicle population from the registered population

(Table III) and the gasoline consumption rates in gallons/vehicle (Table IV) are used for this inventory. The correction factor for four-wheel drive vehicles is a weighted average of the figures for dune buggies and miscellaneous four-wheel vehicles. The emission factors for four-wheel drive vehicles are presented in Table V.

TABLE III

Correction Factor to Estimate Actual Vehicle Population
from the Registered Population[2]

Vehicle Type	Correction Factor
Four-Wheel Drive Vehicles	5.81

TABLE IV

Four-Wheel Drives
Gasoline Consumption Rates
(Gallons/Vehicle)

Month	Gallons/Vehicle
January	9.38
February	10.18
March	8.93
April	9.76
May	9.06
June	6.87
July	8.18
August	6.47
September	8.27
October	8.16
November	11.01
December	9.19
Annual Consumption	105.46

TABLE V

Summary of Emission Factors for Four-Wheel Drive Vehicles
(lb/1000 gallons)

	CO	NOx	SOx	TOG	PM
Four-Wheel Drive Vehicles	1,100	66	2.5	110	8.2

According to a 1977 study by U.C. Davis,[3] snowmobiles are used in 25 counties of the state. The percentage of the total statewide snowmobile usage in each county was established (see Table III) and used to distribute the statewide snowmobile fuel use to 25 counties. Statewide fuel use for four-wheel drive vehicles is allocated to the counties according to the number of four-wheel drive vehicles registered.

The emission factors for snowmobiles are derived from the snowmobiles manufactures tests on eight 1986 model year engines, two each from the four snowmobile engine manufacturers. Based upon the test data, International Snowmobile Industry Association (ISIA) submits that the following emission factors are representative for purposes of establishing a snowmobile emission baseline.[4] The unit "Bhp-hr" is an abbreviation for "Brake horsepower-hour".

TOG + NOx	CO
g/Bhp-hr	g/Bhp-hr
216	564

TOG 95% x 216 = 205.2
NOx 5% x 216 = 10.8

The TOG + NOx emission factor is divided into TOG and NOx with a 95% and 5% split respectively. The PM emission factor is from Booz-Allen and Hamilton (BAH)[5] and the SOx emission factor is determined by ARB staff as the ratio of PM emissions to SOx emissions from the 1987 snowmobile emission inventory.

PM	SOx
g/Bhp-hr	g/Bhp-hr
.2	.006

The population of four-wheel drive vehicles was extrapolated between 1987 and 1991 based on DMV population estimates for 1987 and 1989. The increase in population from 1987 and 1989 was 35.56%, so the increase in population from 1987 and 1991 is estimated to be 35.56% due to a recession where no growth is expected between 1989 and 1991. The growth rate from 1987 to 1991 is estimated to be 35.56%. This growth rate is applied to the emission estimates for 1987 to estimate the 1991 emissions for off-road four-wheel drive vehicles.

TEMPORAL INFORMATION

Most of the annual activity for snowmobiles occurs during the winter and the spring seasons. The weekly activity is uniform on weekdays, but about twice as high on weekends. Daily activity occurs during the daylight hours.

The annual activity for four-wheel drive vehicles occurs year round. The weekly activity is uniform on weekdays, but about twice as high on weekends. Daily activity occurs during the daylight hours. (These temporal activities are standard for recreational type activities).

ASSUMPTIONS

1. The ratio of the actual number of four-wheel drive vehicles in use to the number registered is 5.81 to 1 (Reference 2).

2. Four-wheel drive vehicles are used primarily within the county in which the vehicle is registered. This is an ARB staff assumption.

3. The four-wheel drive vehicle population can be grown by the increase in population from 1987 to 1989 according to DMV and extrapolated to 1991. This population growth factor can be used to grow the emissions from 1987 to 1991 assuming no growth between 1989 and 1991 due to recession.

4. The entire population of snowmobiles in the state of California is estimated at 13,000 units [6] and this estimate is used in this report (There are 8,532 units registered with the California Department of Motor Vehicles[4] (DMV)).

5. The four-wheel drive vehicles are not estimated for the San Francisco air basin, since the Bay Area Air Quality Management District (BAAQMD) estimates these emissions.

CHANGES IN METHODOLOGY

Four-wheel drive vehicle emissions were grown by vehicle population increase. ISIA provided emission factors for TOG, NOx, and CO.

DIFFERENCES BETWEEN 1987 AND 1990 EMISSION ESTIMATES

Off-road four-wheel drive emissions have increased by 36% from 1987 to 1990 due to the increase in vehicle population. The snowmobile emission estimates have increased by a large amount due to the new emission factors and population estimates.

RECOMMENDATIONS

A new survey of off-road four-wheel drive vehicles needs to be completed. The current method of extrapolating on-road four wheel drive vehicle population to off-road use is a poor way to grow the emissions. The old emission factors were completed in 1977 and have been applied to the DMV activity data until 1990.

SAMPLE CALCULATIONS

EMISSIONS ESTIMATES

For the State of California:

Snowmobiles:

Snowmobile population = 13,000 units in California[6]

TOG (13,000 units))(98 hours/unit)(.75 load)(54 HP)(205.2 g/BHP-hr)
/(453.7 g/lb x 2000lb/ton) = 11,667.7 ton/yr

CO (13,000 units)(98 hours/unit)(.75 load)(54 HP)(564 g/BHP-hr)
/(453.7 g/lb x 2000lb/ton) = 32,069.0 ton/yr

NOx (13,000 units)(98 hours/unit)(.75 load)(54 HP)(10.8 g/BHP-hr)
/(453.7 g/lb x 2000lb/ton) = 614.1 ton/yr

SOx (13,000 units)(98 hours/unit)(.75 load)(54 HP)(0.006 g/BHP-hr)
/(453.7 g/lb x 2000lb/ton) = 0.3 ton/yr

PM (13,000 units)(98 hours/unit)(.75 load)(54 HP)(0.2 g/BHP-hr)
/(453.7 g/lb x 2000lb/ton) = 11.4 ton/yr

Calculation of process rate (1000 gallons burned):
(13,000 units)(32.63 gallons/unit)/1000 (gallons/1000 gallons)
= 424 (1000 gallons)

Four-Wheel Drive Vehicles:

El Dorado County gasoline consumption

$$= \text{(1987 registered four-wheel drives in County)} \times \text{(correction factor}^2)$$
$$\times \text{(fuel use factor)}$$

$$= 262 \text{ vehicles} \times 5.81 \times 105.46 \text{ gallons/vehicle-year}$$

$$= 160.53 \times 10^3 \text{ gallons/year}$$

1987 TOG emissions

$$= 160.53 \times 10^3 \text{ gallons/year} \times 110 \text{ lb/}10^3 \text{ gallons} / 2000 \text{ lb/ton}$$

$$= 8.83 \text{ tons/year}$$

1989 TOG emissions

$$= \text{(1987 TOG emissions)} \times \text{(growth factor of 1.3556)}$$

$$= 8.83 \text{ tons/year} \times 1.3556$$

$$= 11.97 \text{ tons/year}$$

DEFINITION OF TERMS

ISIA - International Snowmobile Industry Association
ARB - Air Resources Board
DMV - Department of Motor Vehicles
PSR - Power Systems Research

REFERENCES

1. Department of Motor Vehicles, Off-Highway Vehicles Currently Registered, Annual Reports dated 10/27/89 and 10/30/87, DMV Budget Forecasting Unit.

2. Tyler Research Associates, A Study to Determine the Number of Off-Highway Vehicles for the Purpose of Determining Fuel Tax Paid by Off-Highway Vehicles, prepared for the California Department of Transportation, Project #95229 (February 1978).

3. University of California Cooperative Extension, Recreational Snowmobiling, Davis, California (February 1977).

4. International Snowmobile Industry Association, Comments on the California Air Resources Board Mail Out # 90-70.

5. Booz-Allen & Hamilton, Inc. Off-Road Mobile Equipment Emission Inventory Estimate, Draft January 1992.

6. Power System Research, (phone conversation).

7. Air Resources Board, Methods for Assessing Area Source Emissions in California, September 1991.

PREPARED BY

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D20143

TABLE -I

1990 AREA SOURCE EMISSIONS

ACTIVITY:RECREATIONAL
PROCESS:OFF-ROAD MOTOR VEHICLES
ENTRADNMENT:GASOLINE-CMBSTN
BIAN:SNOW MOBILE

CES: 47514

PROCESS RATE UNIT: 1000 GALLONS BURNED

AB	COUNTY	PROCESS RATE	TOG EMISSIONS (TONS/YEAR)	CO EMISSIONS (TONS/YEAR)	NOX EMISSIONS (TONS/YAER)	SOX EMISSIONS (TONS/YEAR)	PM EMISSIONS (TONS/YEAR)
GBV	ALPINE	12	316.70	870.60	16.70	.00	.30
	INYO	2	58.20	162.00	3.10	.00	.10
	MONO	30	817.20	2,247.30	43.00	.00	.80
LC	LAKE	0	.00	.00	.00	.00	.00
LT	EL DORADO	10	272.50	729.10	14.30	.00	.30
	PLACER	2	51.60	141.70	2.70	.00	.10
MC	AMADOR	14	382.00	1,052.00	20.20	.00	.40
	CALAVERAS	5	135.20	364.00	6.60	.00	.10
	EL DORADO	25	686.00	1,882.00	36.10	.00	.70
	MARIPOSA	2	58.20	162.00	3.10	.00	.10
	NEVADA	23	632.50	1,741.10	33.50	.00	.60
	PLACER	3	75.00	203.00	3.00	.00	.10
	PLUMAS	74	2,015.00	5,502.00	107.00	.10	2.00
	SIERRA	12	316.70	879.00	16.70	.00	.30
	TUOLUMNE	25	699.80	1,923.30	36.80	.00	.70
NC	DEL NORTE	0	.00	.00	.00	.00	.00
	HUMBOLDT	0	.00	.00	.00	.00	.00
	MENDOCINO	0	.00	.00	.00	.00	.00
	SONOMA	0	.00	.00	.00	.00	.00
	TRINITY	2	58.90	162.00	3.10	.00	.10
NCC	MONTEREY	0	.00	.00	.00	.00	.00
	SAN BENITO	0	.00	.00	.00	.00	.00
	SANTA CRUZ	0	.00	.00	.00	.00	.00
NEP	LASSEN	51	1,399.50	3,846.70	73.70	.00	1.40
	MODOC	1	.00	.00	.00	.00	.00
	SISKIYOU	41	1,141.70	3,138.10	60.10	.00	1.10
SC	LOS ANGELES	0	.00	.00	.00	.00	.00
	ORANGE	0	.00	.00	.00	.00	.00
	RIVERSIDE	0	.00	.00	.00	.00	.00
	SAN BERNARDINO	7	184.10	506.10	9.70	.00	.20
SCC	SAN LUIS OBISPO	0	.00	.00	.00	.00	.00
	SANTA BARBARA	0	.00	.00	.00	.00	.00
	VENTURA	0	.00	.00	.00	.00	.00
SD	SAN DIEGO	0	.00	.00	.00	.00	.00
SED	IMPERIAL	0	.00	.00	.00	.00	.00
	KERN	1	22.10	60.70	1.00	.00	.00
	LOS ANGELES	0	.00	.00	.00	.00	.00
	RIVERSIDE	0	.00	.00	.00	.00	.00
SJV	FRESNO	19	515.60	1,417.20	27.10	.00	.50
	KERN	6	169.40	466.40	8.90	.00	.20
	KINGS	0	.00	.00	.00	.00	.00
	MADERA	9	257.00	708.00	13.60	.00	.30
	MERCED	0	.00	.00	.00	.00	.00
	SAN JOAQUIN	0	.00	.00	.00	.00	.00
	STANISLAUS	0	.00	.00	.00	.00	.00
	TULARE	9	257.00	708.60	13.60	.00	.30
SV	BUTTE	21	574.50	1,579.20	30.20	.00	.60
	COLUSA	0	.00	.00	.00	.00	.00
	GLENN	2	58.90	162.00	3.10	.00	.10
	PLACER	0	.00	.00	.00	.00	.00
	SACRAMENTO	0	.00	.00	.00	.00	.00
	SHASTA	14	383.00	1,052.00	20.20	.00	.40
	SOLANO	0	.00	.00	.00	.00	.00
	SUTTER	0	.00	.00	.00	.00	.00
	TEHAMA	2	58.90	162.00	3.10	.00	.10
	YOLO	0	.00	.00	.00	.00	.00
	YUBA	2	58.90	162.00	3.10	.00	.10
	TOTAL* FOR 47514	425	11,667.20	32,069.39	614.20	.10	12.00

FRACTION OF REACTIVE ORGANIC GASES (FROG): .9676

   (REACTIVE ORGANIC GASES (ROG) EMISSIONS = TOG X FROG)

FRACTION OF PM10 (FRPM10): .9940

   (PM10 EMISSIONS = PM X FRPM10)

TABLE -II

1990 AREA SOURCE EMISSIONS

ACTIVITY:RECREATIONAL
PROCESS:OFF-ROAD MOTOR VEHICLES
ENTRAINMENT:GASOLINE-CMBSTN
DIMN:FOUR-WHEEL DRIVES

CES: 54411

PROCESS RATE UNIT: 1000 GALLONS BURNED

AB	COUNTY	PROCESS RATE	TOG EMISSIONS (TONS/YEAR)	CO EMISSIONS (TONS/YEAR)	NOX EMISSIONS (TONS/YAER)	SOX EMISSIONS (TONS/YEAR)	PM EMISSIONS (TONS/YEAR)
GBV	ALPINE	1	.00	.40	.00	.00	.00
	INYO	18	.90	10.00	.50	.00	.10
	MONO	9	.50	5.00	.30	.00	.00
LC	LAKE	66	3.70	36.60	2.20	.10	.30
LT	EL DORADO	60	3.30	32.20	2.00	.10	.30
	PLACER	20	1.10	11.00	.70	.00	.10
MC	AMADOR	98	5.40	54.00	3.30	.10	.40
	CALAVERAS	60	3.30	32.30	2.70	.10	.30
	EL DORADO	157	8.70	86.80	5.20	.10	.60
	MARIPOSA	14	.80	7.70	.50	.00	.00
	NEVADA	82	4.50	45.30	2.70	.10	.30
	PLACER	28	1.50	15.60	.90	.00	.10
	PLUMAS	39	2.10	21.40	1.40	.00	.60
	SIERRA	5	.30	3.30	.10	.00	.00
	TUOLUMNE	106	5.80	58.40	3.50	.10	.40
NC	DEL NORTE	53	3.00	29.30	1.80	.00	.30
	HUMBOLDT	76	5.30	53.00	3.10	.10	.40
	MENDOCINO	168	9.30	92.30	5.60	.30	.70
	SONOMA	36	2.00	20.60	1.20	.00	.10
	TRINITY	22	1.20	11.90	.70	.00	.10
NCC	MONTEREY	121	6.60	66.30	3.90	.10	.50
	SAN BENITO	22	1.20	12.10	1.10	.00	.10
	SANTA CRUZ	46	2.60	25.10	1.50	.00	.10
NEP	LASSEN	143	7.10	78.60	4.70	.10	.50
	MODOC	19	1.10	10.80	.70	.00	.10
	SISKIYOU	39	2.20	22.00	1.40	.00	.10
SC	LOS ANGELES	3682	202.50	2,024.70	121.50	4.40	15.00
	ORANGE	1295	74.10	743.40	42.30	2.10	7.30
	RIVERSIDE	852	47.30	472.80	28.30	1.00	3.50
	SAN BERNARDINO	1147	63.00	630.90	37.80	1.40	4.70
SCC	SAN LUIS OBISPO	256	14.10	141.10	8.40	.30	1.10
	SANTA BARBARA	124	6.80	69.30	4.10	.10	.70
	VENTURA	428	23.50	235.40	14.10	.50	1.80
SD	SAN DIEGO	2812	154.70	1,546.30	92.70	3.50	11.50
SED	IMPERIAL	229	12.60	126.10	7.60	.30	.90
	KERN	61	3.40	34.10	2.00	.10	.20
	LOS ANGELES	64	3.50	35.10	2.00	.10	.30
	RIVERSIDE	314	17.20	172.10	10.30	.40	1.40
	SAN BERNARDINO	277	15.20	152.10	9.10	.40	1.10
SJV	FRESNO	355	19.50	195.50	11.80	.40	1.50
	KERN	312	17.20	172.00	10.30	.40	1.30
	KINGS	45	2.50	24.80	1.50	.10	.20
	MADERA	42	2.30	22.80	1.40	.00	.10
	MERCED	115	6.30	63.00	3.80	.10	.50
	SAN JOAQUIN	349	18.80	188.50	11.30	.50	1.40
	STANISLAUS	304	16.80	168.00	10.10	.40	1.30
	TULARE	267	14.60	146.70	8.80	.30	1.10
SV	BUTTE	278	15.30	152.60	9.20	.40	1.10
	COLUSA	68	3.70	37.00	2.20	.10	.10
	GLENN	121	6.60	66.70	4.00	.10	.20
	PLACER	184	10.20	102.10	6.10	.20	.30
	SACRAMENTO	716	37.60	405.60	23.60	.20	.80
	SHASTA	268	14.80	147.60	8.80	.30	1.10
	SOLANO	31	1.80	16.90	.90	.00	.10
	SUTTER	95	5.20	52.40	3.10	.10	.40
	TEHAMA	232	12.70	127.40	7.60	.10	.90
	YOLO	146	8.00	80.40	4.90	.10	.60
	YUBA	64	3.50	35.10	2.20	.10	.30
	TOTAL* FOR 54411	**17648**	**970.62**	**9,709.59**	**582.30**	**20.79**	**72.11**

FRACTION OF REACTIVE ORGANIC GASES (FROG):   .9676

   (REACTIVE ORGANIC GASES (ROG) EMISSIONS = TOG X FROG)

FRACTION OF PM10 (FRPM10):   .9940

   (PM10 EMISSIONS = PM X FRPM10)